## REPORT DOCUMENTATION PAGE

Form Approved

OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Artington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

| 1. AGENCY USE ONLY (Leave blank)   | 2. REPORT DATE | 3. REPORT TYPE AND | D DATES COVERED                       |  |  |  |
|--|----------------|--------------------|---------------------------------------|--|--|--|
| 1. AGENCY USE ONLY LEGAVE Blanky   | 9/23/99        | FINAL 01 JU        | IN 97 - 31 MAY 99                     |  |  |  |
| 4. TITLE AND SUBTITLE  |                |                    | 5. FUNDING NUMBERS                    |  |  |  |
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| DYNAMIC THRESHOLD-VOLTAGE MOSFET   |                |                    | FDN00014-97-1-0699                    |  |  |  |
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| 6. AUTHOR(S)   |                |                    |                                       |  |  |  |
|  |                |                    |                                       |  |  |  |
| PROF. CHENMING HU  |                |                    |                                       |  |  |  |
|  |                |                    |                                       |  |  |  |
| 7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)  |                |                    | 8. PERFORMING ORGANIZATION            |  |  |  |
| THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, BERKELEY  |                |                    | REPORT NUMBER                         |  |  |  |
|  |                | ILA, BEKKELEY      |                                       |  |  |  |
| C/O SPONSORED PROJECTS OFFICE 336 SPROUL HALL  |                |                    |                                       |  |  |  |
| BERKELEY, CA 94720-59  | 40             |                    |                                       |  |  |  |
| BERRELEI, CA 94/20-39  | 40             |                    |                                       |  |  |  |
| 9. SPONSORING / MONITORING AGENCY NAMES(S) AND ADDRESS(ES)   |                |                    | 10. SPONSORING / MONITORING           |  |  |  |
| OFFICE OF NAVAL RESEARCH   |                |                    | AGENCY REPORT NUMBER                  |  |  |  |
| PROGRAM OFFICER: CLIFFORD G. LAU   |                |                    |                                       |  |  |  |
| ONR: 311   |                |                    |                                       |  |  |  |
| 800 NORTH QUINCY STREE   | ET .           |                    | ,                                     |  |  |  |
| ARLINGTON, VA 22217-1  | 5660           |                    |                                       |  |  |  |
| 11. SUPPLEMENTARY NOTES  |                |                    |                                       |  |  |  |
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|  |                |                    |                                       |  |  |  |
|  |                |                    | 12. DISTRIBUTION CODE                 |  |  |  |
| a. DISTRIBUTION / AVAILABILITY STATEME   | :N1            |                    | 12. DISTRIBUTION CODE                 |  |  |  |
| APPROVED FOR PUBLIC RI   | FT FACE        |                    | ,                                     |  |  |  |
| AFFROVED FOR FUBLIC KI   | LLEASE         |                    |                                       |  |  |  |
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|  |                |                    |                                       |  |  |  |
| 13. ABSTRACT (Maximum 200 words)   |                |                    |                                       |  |  |  |
| ·  |                |                    | · :                                   |  |  |  |
| A Dynamic Threshold MOS (DTMOS) transistor has the unique ability to operate   |                |                    |                                       |  |  |  |
| at 0.5V with high speed and current wile delivering a low off-state leakage.   |                |                    |                                       |  |  |  |
| This project investigated the possibility of using DTMOS at Vdd 0.5V to  |                |                    |                                       |  |  |  |
| achieve higher circuit performance.  |                |                    |                                       |  |  |  |
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| 14. SUBJECT TERMS                     | 15. NUMBER OF PAGES                      |   |                            |
|---------------------------------------|--|---|----------------------------|
|                                       |  |   | 2                          |
| Low-power, CMOS                       |  |   | 16. PRICE CODE             |
|                                       |  |   |                            |
| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
| unclassified                          | unclassified                             | unclassified                            | UL.                        |

Standard Form 298 (Rev. 2-89) Prescribed by ANISE Sad Z39-18 298-102

# DYNAMIC THRESHOLD-VOLTAGE MOSFET

## **Professor Chenming Hu**

#### 1. OVERVIEW

In October 1994, we proposed the novel DTMOS technology that has a performance at 0.5V far exceeding what has been considered possible.

Reducing the power supply voltage is a very effective way of reducing the power consumption of IC's. The 1997 National Technology Roadmap for Semiconductors projected that the power supply voltage will scale with the channel length in direct proportion. Today's 0.25µm CMOS technology is powered by 2.5V power supplies. 1 volt power supply is projected for the 0.1µm technology. It is not clear whether CMOS technology can be scaled below 0.05µm and 0.5V because of a fundamental conflict between speed performance and power dissipation.

We proposed a revolutionary device innovation to satisfy both the high-speed and low-leakage requirements. We proposed to make  $V_T$  a function of the gate voltage,  $V_g$ . Specifically,  $V_T$  shall be low (0.1V) when the transistor is on  $V_g = 0.5V$ ) so that circuit speed will be excellent;  $V_T$  will be high (0.4V) when the transistor is low ( $V_g = 0V$ ) so that leakage current will be low too. This dynamic  $V_T$  is achieved by simply shorting the gate to the body. Implementation in SOI is straightforward because the body is otherwise electrically isolated; only a contact layout change is required to turn a conventional MOSFET into a DTMOS of either n or P channel type. SOI has the added benefit of being low in capacitance, which is good for low power operation, and being potentially superior to bulk technology in density (good for power too) and even manufacturability in the long run. DTMOS, however, can also be implemented in bulk using a triple well technology.

In this AASERT project, DTMOS was investigated for use with  $V_{dd} > 0.5V$ . To prevent the body-source to draw forward bias current, special circuit schemes need to be used.

# 2. BRIEF SUMMARY OF MAJOR CONTRACT ACCOMPLISHMENTS

It was demonstrated through circuit simulation that DTMOS is particularly attractive for low-voltage pass-gate logic circuits. Several circuits schemes were found to allow DTMOS operation at  $V_{dd} > 0.5V$ .

## 3. TECHNOLOGY TRANSFERRED

- DTMOS technology was transferred to IBM and AMD.
- DTMOS technology has been used at NTT, Toshiba and Sharp for 0.5V circuit design.